Lecture Notes in Networks and Systems 825

Kohei Arai *Editor*

Intelligent Systems and Applications

Proceedings of the 2023 Intelligent Systems Conference (IntelliSys) Volume 4

Springer

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Preface

It gives me immense pleasure and privilege to present the proceedings of Intelligent Systems Conference (IntelliSys) 2023 which was held in a hybrid mode on 7 and 8 September 2023. IntelliSys was designed and organized in Amsterdam, the Netherlands, that aimed to advance and apply artificial intelligence to real world.

IntelliSys is an annual conference which provides the platform to researchers, academics and industry practioners across the globe to share their valuable findings and insights. The conference witnessed huge international participation with delegates from all parts of the world.

A technological revolution has hit the world where Artificial Intelligence, Robotics, Machine Vision and Ambient Intelligence have gained preeminence over all the other fields. The researches in these fields have managed to give workable solutions to many intriguing problems. They also let us see through what the future would look like if artificial intelligence was entwined in our life. One of the meaningful and valuable dimensions of this conference is the way it lets researchers report and discuss these breakthroughs.

The aim was to further increase the body of knowledge in this specific area by providing a forum to exchange ideas and build international links. Authors from 50+ countries submitted a total of 605 papers to be considered for publication. Each paper was reviewed on the basis of originality, novelty and rigorousness. After the reviews, 239 were accepted for presentation, out of which 227 papers are finally being published in the proceedings. We would like to extend our gratitude to all the learned guests who participated on site as well as online to make this conference extremely fruitful and successful and also special note of thanks to the technical committee members and reviewers for their efforts in the reviewing process. Special acknowledgment to all the distinguished keynote speakers.

We are extremely glad to bring forth the precious researches from our learned scholars and hope to whet the appetite of our readers. Your continued support and enthusiasm would motivate us to grow and evolve exponentially.

Saga, Japan Kohei Arai

Contents

Mobile Application for the Detection of UV Levels in México

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Abstract. Studies on the UV index (UVI) are becoming increasingly important worldwide due to the constant deterioration to which the habitat of modern man is subject. For this reason, humans get exposed to UV radiation. Solar energy is necessary for the life of living beings. However, it has also generated alterations in the ozone layer, causing the direct entry of UV rays to the earth's surface, thus generating skin diseases in humans. This research describes how information technologies (IT) help the optimal management of this problem through the development of a mobile application, which allows for the identification of the level of UV ray indices; thus, the user obtains a recommendation based on the classification proposed by the World Health Organization. This research will review the development process of the mobile application (App), as well as the connection parameters provided by the Weather Underground server, which allowed the construction of the API for the recovery of data obtained from the readings of the Meteorological Unit of the Technological University of Morelia (UM–UTM). Finally, it is important to interpret these data to help predict the circumstances that generate high levels of the UVI and propose recommendations that may benefit the user of the App. Thus helping in the care of the incidences of environmental pollutants, as well as the relevance of adopting adequate protection measures with which the human being is unfamiliar.

Keywords: Mobile application · API · Weather station · UV rays

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1 Introduction

1.1 A Subsection Sample

Solar energy is necessary for the life of living beings. However, due to climate change, global warming, emission of gases, and the greenhouse effect, alterations have been generated in the ozone layer, causing the direct entry of UV rays to the earth's surface. For several decades, an increase in skin diseases (cancer) has been detected worldwide, mainly in people with fair skin and who are linked to sun exposure and its ultraviolet (UV) component, as well as the erroneous social perception that tanning is desirable and healthy.

The UVI (UV index) is an indicator that represents the ability to produce skin lesions, which serves as a means to raise awareness in the population and warn people of the need to adopt protective measures when exposed to UV radiation. The UVI is the result of international work by the World Health Organization (WHO) in collaboration with the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), the International Commission on Non-Ionizing Radiation Protection (ICNIRP), and the German Federal Office for Radiation Protection (Bundesamt für Strahlenschutz, BfS); to harmonize the way of communicating the UV index and to improve its use as an educational instrument for promoting sun protection. Therefore, this research is based on developing a mobile application (App) that lets users know about the UVI level that is held at that time to generate a preventive action based on a health approach, integrating sun protection and the prevention of skin cancer. The App obtains a set of data stored in a dataset obtained from the UM – UTM, which, through its application programming interface (API), informs about the UVI. This data serves as a starting point for users to obtain a recommendation related to the identified level of the UVI and to protect themselves.

2 Theoretical Background

2.1 Solar Radiation and Electromagnetic Spectrum

Electromagnetic radiation is the flow of energy that arises from a source in the form of waves. For example, solar radiation is the energy produced by that star and is the product of hydrogen reactions that, in turn, are generated by nuclear fusion; radiation propagates in all directions through space by electromagnetic waves. These waves do not need a material medium to reproduce, so they can pass through interplanetary and interstellar space and reach the Earth. A wave is a variation of energy that is transmitted through space or a natural environment. It consists of ridges (the highest point of the wave) and valleys (the lowest point of the wave); in addition, the waves have a length (maximum distance between identical points (adjacent crests) in the adjacent cycles of a waveform signal) [16], as shown in Fig. 1. In 2011, NASA (National Aeronautics and Space Administration) defined the electromagnetic spectrum as the full range of all electromagnetic radiation. And it is considered an economic and technical resource, so its effective use can impact the economy and prosperity of a region [13].

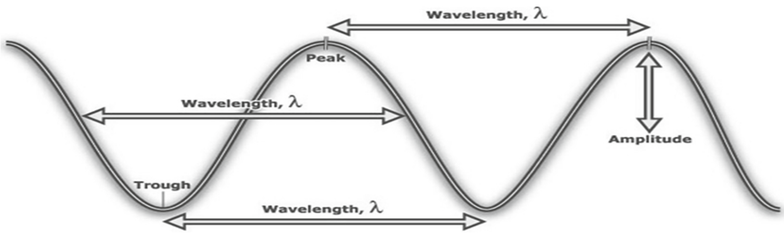

Fig. 1. Composition of an electromagnetic wave.

The electromagnetic spectrum is divided into regions (ranges), which are: (1) Radio, (2) Microwave, (3) Infrared, (4) Visible (to the human eye), (5) Ultraviolet, (6) X-rays, and (7) Gamma Rays [13]. However, these divisions have no rigid borders [3]. So there are transpositions between neighboring regions [13]. The electromagnetic spectrum does not have well-defined upper and lower limits, and the energy of a tiny fraction of radiation, called a photon, is inversely proportional to its wavelength, so the shorter the wavelength, the more effective the energy content. For example, the International Agency for Research on Cancer defines solar radiation as essentially optical radiation (energy that includes ultraviolet, visible, and infrared radiation). However, shorter wavelength (ionizing) radiation, such as more prolonged wavelength radiation (microwaves and radiofrequency), is present [7].

The visible region (between 400 nm and 700 nm) corresponds to the radiation that can perceive the sensitivity of the human eye and includes the colors: (1) violet (420 nm), (2) blue (480 nm), (3) green (520 nm), (4) yellow (570 nm), (5) orange (600 nm) and 6) red (700 nm). Violet light is more energetic than red light because it has a smaller wavelength. Therefore, radiation with the shortest wavelengths corresponds to violet light, called ultraviolet radiation. The electromagnetic spectrum is divided into Ionizing Radiation (IR) and Non-Ionizing Radiation (NIR), described in Table 1.

The human being interacts permanently with the RNI through the urban environment; this situation has generated great concern in the health sector due to the discoveries related to the adverse effects that it causes. Increased exposure to NIR, to which humans are exponentially exposed to new devices and wireless access services, is one of the possible reasons for the early onset of diseases and health disorders [10].

The fundamental difference between NIR and IR is that the latter has enough energy to Ionize matter in a High-Frequency range, as shown in Fig. 2.

IR harms human health and can cause multiple diseases, including skin cancer. As a result, there was an increase in the attention to this problem worldwide in scientific, social, and government activities [8]. This attention has made it possible to study emissions and find preventive measures to reduce this factor that impacts human health. However, the modern world's high scientific and technological development and the non-rational nature of resource exploitation practices have led to environmental pollution.

Table 1. Ionizing radiation and non-ionizing radiation.

IR.- Type of radiation that has enough energy to remove an electron (negative particle) from an atom or molecule and cause its ionization. Ionizing radiation produces chemical changes in cells and damages DNA. These damages increase the risk of diseases such as cancer. Ionizing radiation comes from natural sources, such as the chemical element called radon, cosmic rays (rays that enter the Earth's atmosphere from outer space), medical radiography, computed tomography (CT), or positron emission tomography (PET) devices [6]
NIR. A type of radiation that does not have enough energy to remove an electron (negative particle) from an atom or molecule. Non-ionizing radiation includes visible light, infrared and ultraviolet light, microwaves, radio waves, and radio frequency energy generated by mobile phones. It has been established that most types of non-ionizing radiation do not cause cancer [6]

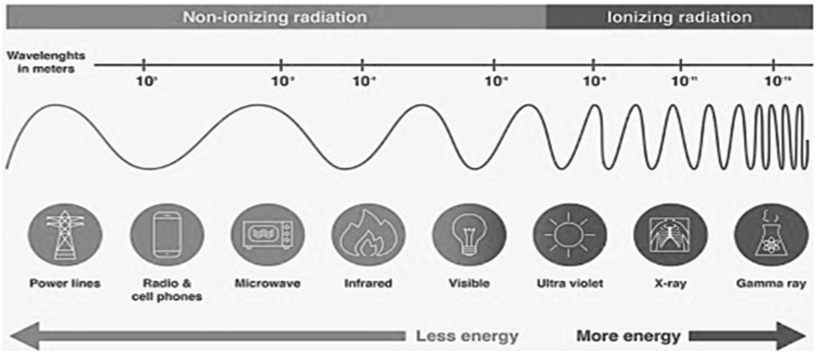

Fig. 2. Composition of the electromagnetic spectrum.

2.2 Atmosphere

The atmosphere is a mixture of suspended gases and aerosols (solid and liquid particles) [15]. Oxygen (O_2) and nitrogen (N_2) are the main components that make up the atmosphere (99%): O_2 constitutes 21% and N2 78%; that is, if the atmosphere were formed only by N_2 and O_2, you could breathe in it without any problem. The atmosphere contains: (1) the air we breathe, (2) protects life from harmful radiation from the sun, (3) helps prevent the planet's heat from escaping into space, (4) is an important element of the water cycle, (5) keeps the climate on Earth moderate compared to that of other planets. Atmospheric gases become thinner as you ascend.

The atmosphere decreases its density until it is unified with outer space. The atmosphere is divided into four layers according to temperature: (1) the troposphere, (2) the stratosphere, (3) the mesosphere, and (4) the thermosphere. The Sun emits a large amount of energy to the Earth, of which only 6% to 7% corresponds to UV radiation. The UV region covers the range of wavelengths from 100 to 400 nm and is divided into three categories: (1) UV-C, (2) UV-B, and (3) UV-A). The shorter the wavelength of UV radiation, the more biologically harmful it is [9]. The classification and range of the waves are shown in Table 2.

Table 2. UV classification.

Class of UV	Wavelength range, nm
UV-A	400–315
UV-B	315–280
UV-C	280–100

When sunlight passes through the atmosphere, the ultraviolet component comprises about 95% UV-A and 5% UV-B; UV-C and most UV-B rays are removed from extraterrestrial radiation due to stratospheric ozone [7]. The highest ozone concentration is found at altitudes between 19 and 30 km above the earth's surface, as shown in Fig. 3. Ozone is the combination of three oxygen atoms. It becomes a naturally produced gas in the stratosphere [17].

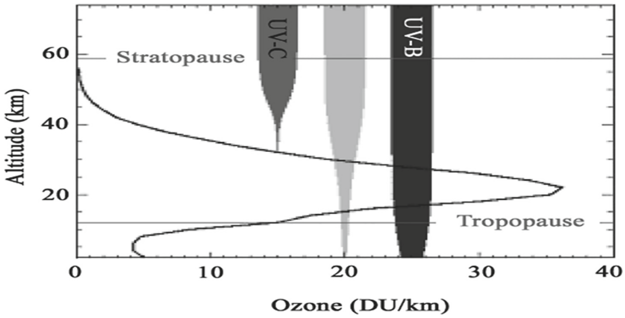

Fig. 3. Vertical distribution of UV radiation and atmospheric ozone.

Exposure to sunlight, specifically ultraviolet radiation, has positive and adverse health effects [18]. Excessive sun exposure has been of more significant concern due to its negative impact on humans, terrestrial and aquatic ecosystems, materials, and air quality [14]. The intensity of the ultraviolet rays of sunlight depends on various environmental factors, which are listed in Table 3.

2.3 UV Index

In 1992 the UV index program was generated, which was developed by Environment Canada (EC) and aimed to provide information on UV radiation (280–400 nm) to the public through an indicator that was easy to understand and that quantified the levels of UV radiation that were expected for the next day. The index is based on the degree to which solar radiation interacts with the skin to produce burns or "erythema"; it is defined by formula 1.

$$I_{UV} = k_{er} \bullet \int_{250nm}^{400nm} E_{\lambda} \bullet s_{er}(\lambda) d\lambda \tag{1}$$

Table 3. Environmental factors that impact UV rays.

Position of the sun; the higher the position of the sun, the greater the ultraviolet radiation. On the other hand, the incidence of sunlight varies with seasons, so the intensity of ultraviolet rays depends not only on the time of day but on the month of the year
Latitude. The closer to the Earth's equator, the greater the radiation
Altitude. As altitude increases, the atmosphere becomes lighter and absorbs fewer ultraviolet rays. The intensity of radiation increases between 10 and 12% per thousand meters of altitude
Cloudiness. Although the radiation intensity is maximum when the sky is clear, it can increase on cloudy days due to the reflection of fine water particles
Ozone layer. It absorbs some of the ultraviolet radiation that reaches the Earth's surface. The ozone concentration varies throughout the year and even on the same day
Soil reflection. Different surfaces reflect and scatter ultraviolet radiation in different ways. For example, recent snow can reflect up to 80%, dry sand from a beach reflects up to 15%, and seawater foam around 25%

where:

- $E\lambda$ is the solar spectral irradiance (measure of the solar spectrum transmitted through the atmosphere) expressed in W/(m 2.nm).
- ser(λ) is the reference action spectrum for erythema.
- ker is a constant equal to 40m2/W.

The index is dimensionless and expressed as a value greater than zero; the higher, the greater the probability of skin and eye lesions and the less time it takes for them to occur. EC recommends the third-generation Brewer ozone spectrophotometer (Mark III) to measure solar radiation and ozone in the ultraviolet (UV) region of the spectrum, being also significantly superior to the other generations [1], so manufacturers only produce this model. The UV index is now used in more than 100 countries worldwide. It has been defined as the standard public awareness program on UV radiation by the World Meteorological Organization and the World Health Organization [15]. According to the Secretary of Health (SSA), UV exposure continues to be a problem in Mexico, and skin cancers are expected to cause approximately 1300 cases a year [19].

2.4 Skin Diseases

The skin of the human body is the largest organ and the first line of defense against any agent with which the human being may have contact, whether physical, chemical, or by solar radiation. This large organ spread throughout the body contains three primary layers, which are: (1) epidermis, (2) dermis, and (3) hypodermis [12], which is shown in Fig. 4.

There are several ways to expose yourself to the sun's rays, for recreation, sports, tanning, work, or simply traveling in a car for a specific time with punctual exposure to some part of the body. Any of these exposures carry a lower or higher degree of risk for contracting a skin disease.

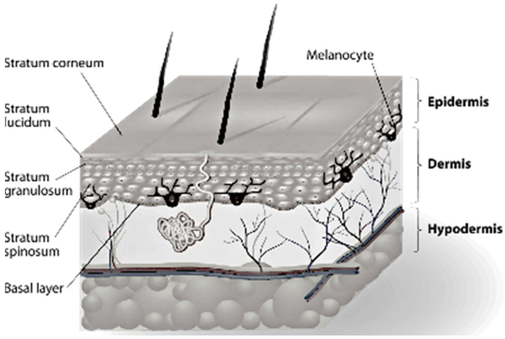

Fig. 4. Primary layers of the skin.

The biological effects of sun exposure are very diverse and depend on its wavelength, penetration into the skin, and exposure time, and may appear years later. In the short term, the following stand out (1) erythema, (2) sunburn, (3) photo dermatoses, and (4) immunosuppression [5]. In the long term, (1) photo-carcinogenesis and (2) photo-aging and its effects are shown in Table 4.

The incidence of skin cancer is increasing in a worrying way around the world. This increase is because sun exposures accumulate throughout life, and short but intense sun exposures increase the risk of skin cancer, mainly if the exposure is sufficient to cause sunburn, primarily if it occurs in childhood. The skin has built natural protection against ultraviolet light that allows protection from skin disorders that it causes. The main natural or endogenous protection mechanisms act in two ways absorbing radiation or deflecting it. Melanin is the essential endogenous protective factor available to the skin.

It works by absorbing radiation with wavelengths between 350–1,200 nm; sun exposure stimulates its production, which translates into tanning. However, not all people tolerate the harmful effects of UV rays. In the same sun exposure, the skin organ does not show the same changes in all people, and there is enormous individual variability. Due to people's socio-cultural context, it is impossible to become aware of the damage they may be receiving from solar radiation. UV radiation is one of the physical agents that cause mutations in the most diverse organisms on our planet and is linked to the processes of photocarcinogenesis [20].

2.5 Automatic Weather Station (AWS)

A weather station is a set of instruments that are integrated into a physical space intended to measure and record various meteorological variables regularly. These data are used to elaborate predictions from numerical models and climate studies, save lives and measure extreme weather events. Meteorological data can be collected by multiple instruments, as shown in Table 5.

An AWS is an autonomous version of a weather station, as the power source is usually one or more solar panels connected to several rechargeable batteries, carrying the automation of the traditional weather station, and aiming to decrease energy consumption and human labor. Measurements can be made in remote or uninhabited areas; the

Table 4. Diseases caused by UV rays.

Disease	Effects
Solar erythema	It is an inflammatory response of the skin that appears within a few hours of sun exposure and reaches its maximum intensity within 12–24 h. In extreme exposure cases, it can become a sunburn of 1° or 2° superficial degree, with blistering. This reaction is a measurement system for the biological effect of ultraviolet rays
Immunosuppression	It is induced by UVB and, to a lesser extent, by UVA, is a consequence of morphological and functional alteration of epidermal Langerhans cells
Photo dermatoses	It is a term that encompasses a set of skin diseases produced or triggered by sun exposure, mainly UVA
Photoaging or extrinsic skin aging	It is characterized by rough, dry skin without elasticity, deep and thick wrinkles, telangiectasias, lentigines, and pigmentation alterations. It appears due to repeated and prolonged exposure to the sun, especially UVA radiation. The exposed areas are the most affected such as the face, neck, nape, and back of hands. Its intensity depends on the type of skin and the total dose of radiation accumulated over a lifetime
Photo carcinogenesis	The induction of precancerous lesions and carcinomas on the skin by sun exposure is known from epidemiological data from case-control studies and geographic correlation studies that support this relationship [2]

Table 5. Instruments for the collection of meteorological data.

Instrument	Parameter
Thermometer	Temperature
Rain gauge	Precipitation
Hygrometer	Humidity
Barometer	Atmospheric pressure
Anemometer	Wind speed
Weathervane	Wind direction
Pyranometer	Solar radiation
Spectro-radiometer	UV radiation

structure of an AWS can be seen in Fig. 5. Model-based measurements or calculations can determine the UV index. There are two possible measurement-based approaches: the first is to use a spectro-radiometer and calculate the UV index. The second is to

use a broadband detector calibrated and programmed to provide the UV index directly; through this method, the Meteorological Unit of the Technological University of Morelia (UM-UTM) makes its measurement, which is located as shown in Fig. 6.

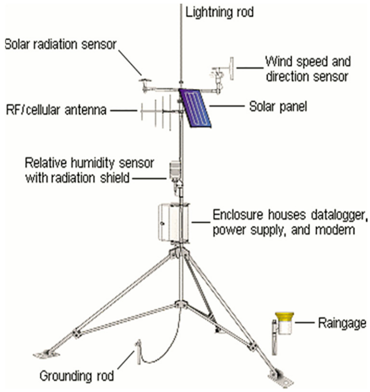

Fig. 5. Weather station.

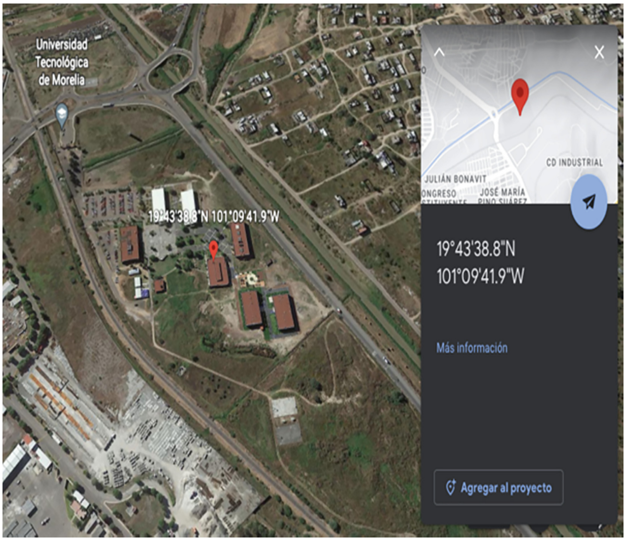

Fig. 6. Location of the UM-UTM.

The UM-UTM UV index sensor measures the sunburning portion of the UV spectrum using global solar UV radiation data (the sum of the components of directly transmitted solar UV rays and those scattered in the atmosphere).

3 Methodology

Once the problem generated by the high level of UV rays and the damage it causes in humans was identified, the UV levels were measured through the meteorological unit of the renewable energy laboratory of the Technological University of Morelia (UM-UTM). These levels are stored in a dataset, which allows their analysis through data science. It was defined that the support and scope of the research are based on different approaches, among which are the approach: (1) experimental, (2) exploratory, (3) descriptive, and (4) correlational [4]. For the development of this research, a set of stages were defined shown in Fig. 7.

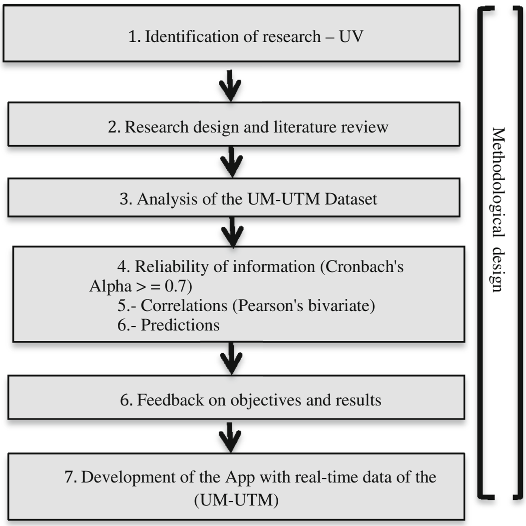

Fig. 7. Methodological model of the research.

The Dataset of the UM-UTM has been registered since 2019 to date and has approximately 10,000 records of different variables. This data allowed us to know the behavior of the levels of UV rays in the all months of 2022 and show in Fig. 8, the month of September reached the highest levels of UV exposure.

The stored dataset obtained from the UM-UTM is analyzed using different mathematical algorithms. Therefore, it is essential to know the data's reliability by applying Cronbach's Alpha study [11], which is based on formula 2.

$$\alpha = \frac{k}{k-1}\left[1 - \frac{\sum s^2}{{s_T}^2}\right] \tag{2}$$

where:

- K = Number of items on the scale.
- S^2i = Variance of item i.

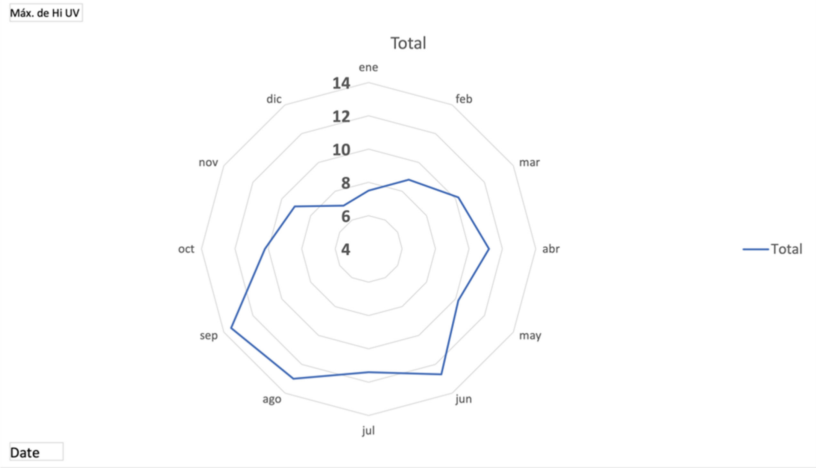

Fig. 8. UV index september 2022.

- S^2t = Variance of individuals' observed scores.

An acceptable reliability level must be higher than 0.7 [4], so the result obtained in this study was satisfactory, with a value of 0.823; the analysis results are shown in Table 6.

Once the information analyzed was reliable, we proceeded to generate the study of correlations through Pearson's bivariate method to find the relationship between the essential variables of the study. Those that impact the generation of UV rays were selected; see Table 7.

The explanation of the most significant correlation of the study is shown in Table 8.

4 Results

The digital proposal includes the development of a mobile application (App) that presents the values of the UV index in real-time obtained by the Meteorological Unit of the Technological University of Morelia (UM-UTM). To achieve the communication and receiving of the data of the Meteorological Unit, three key processes are involved, which are described below:

4.1 Preparing the Weather Data Server

The set of data generated on the measurements of the Meteorological Unit must be stored on a server; for this purpose, this proposal uses the Weather Underground platform, which allows the storage of data from actual weather stations to provide weather forecasts from around the world. The Meteorological Unit of the Technological University of Morelia was created successfully using the Weather Underground server. With this, we obtain access codes that allow the Meteorological Unit to send the readings to the server continuously, as seen in Fig. 9.

Table 6. Reliability of the UM-UTM dataset.

Temp	Hi	Low	Heat		Rain	Solar	UV	UV	Hi	TOTAL		
Out	Temp	Temp	Index	Rain	Rate	Energy	Index	Dose	UV		k	10
23	23	23	23	0	0	18	4	1	4	117	Σvi	237.520
23	23	23	23	0	0	21	4	1	5	123	Vt	914.979
23	23	23	23	0	0	19	4	1	4	118		
23	23	22	23	0	0	19	3	1	3	117	Sección 1	1
22	22	22	22	0	0	10	1	0	1	102	Sección 2	0.740
22	22	22	22	0	0	8	1	0	1	98	Absoluto S2	0.740
22	22	22	21	0	0	5	0	0	1	92		
21	22	21	21	0	0	2	0	0	0	86	α	0.823
20	21	20	20	0	0	0	0	0	0	80		
19	20	19	19	0	0	0	0	0	0	78		
9	10	9	10	0	0	0	0	0	0	38		
9	9	9	9	0	0	0	0	0	0	37		

(*continued*)

Table 6. *(continued)*

Temp	Hi	Low	Heat		Rain	Solar	UV	UV	Hi	TOTAL		
Out	Temp	Temp	Index	Rain	Rate	Energy	Index	Dose	UV		k	10
9	9	9	9	0	0	0	0	0	0	37		
9	9	9	9	0	0	0	0	0	0	36		
11	11	9	11	0	0	2	0	0	0	43		
12	12	11	12	0	0	7	0	0	1	55		
14	14	12	14	0	0	11	1	0	1	68		
15	15	14	15	0	0	16	2	0	2	80		
17	17	16	17	0	0	20	3	1	3	93		
20	20	17	20	0	0	24	4	1	4	109		
21	21	20	21	0	0	27	5	1	5	121		
22	22	21	22	0	0	30	6	1	6	131		
23	24	22	23	0	0	33	7	1	7	141		
24	24	23	24	0	0	34	7	2	8	146		

Table 7. Correlations of the UM-UTM dataset.

		Temp Out	Hi Temp	Low Temp	Heat In	Rain	Rain Rate	Solar Energy	UV Index	UV Dose	Hi UV
Temp Out	Correlación de Pearson	1	0.994**	0.993**	0.995**	−0.026	−0.019	0.474**	0.449**	0.449**	0.457**
	Sig. (bilateral)		0	0	0	0.065	0.174	0	0	0	0
	N	5025	5025	5025	5025	5025	5025	5018	5018	5018	5018
Hi Temp	Correlación de Pearson	0.994**	1	0.994**	0.989**	−0.002	0.006	0.429**	0.408**	0.408**	0.416**
	Sig. (bilateral)	0		0	0	0.864	0.671	0	0	0	0
	N	5025	5025	5025	5025	5025	5025	5018	5018	5018	5018
Low Temp	Correlación de Pearson	0.993**	0.994**	1	0.989**	−0.023	−0.016	0.411**	0.396**	0.396**	0.403**
	Sig. (bilateral)	0	0		0	0.104	0.245	0	0	0	0
	N	5025	5025	5025	5025	5025	5025	5018	5018	5018	5018
Heat In	Correlación de Pearson	0.995**	0.989**	0.989**	1	−0.021	-0.015	0.468**	0.443**	0.443**	0.452**
	Sig. (bilateral)	0	0	0		0.143	0.303	0	0	0	0
	N	5025	5025	5025	5025	5025	5025	5018	5018	5018	5018
Rain	Correlación de Pearson	−0.026	−0.002	−0.023	−0.021	1	0.937**	−0.030*	−0.025	−0.025	−0.026

(*continued*)

Table 7. (*continued*)

		Temp Out	Hi Temp	Low Temp	Heat In	Rain	Rain Rate	Solar Energy	UV Index	UV Dose	Hi UV
	Sig. (bilateral)	0.065	0.864	0.104	0.143		0	0.036	0.072	0.072	0.066
	N	5025	5025	5025	5025	5025	5025	5018	5018	5018	5018
Rain Rate	Correlación de Pearson	0.019	0.006	-0.016	−0.015	.937**	1	−0.026	−0.022	−0.022	−0.023
	Sig. (bilateral)	0.174	0.671	0.245	0.303	0		0.068	0.114	0.115	0.103
	N	5025	5025	5025	5025	5025	5025	5018	5018	5018	5018
Solar Energy	Correlación de Pearson	0.474**	0.429**	0.411**	0.468**	0.030*	-0.026	1	0.967**	0.967**	0.968**
	Sig. (bilateral)	0		0	0	0.036	0.068		0	0	0
	N	5018	5018	5018	5018	5018	5018	5018	5018	5018	5018
UV Index	Correlación de Pearson	0.449**	0.408**	0.396**	0.443**	−0.025	-0.022	0.967**	1	1.000**	.993**
	Sig. (bilateral)	0	0	0	0	0.072	0.114	0		0	0
	N	5018	5018	5018	5018	5018	5018	5018	5018	5018	5018
UV Dose	Correlación de Pearson	0.449**	0.408**	0.396**	0.443**	-0.025	-0.022	0.967**	1.000**	1	0.993**
	Sig. (bilateral)	0	0	0	0	0.072	0.115	0	0		0
	N	5018	5018	5018	5018	5018	5018	5018	5018	5018	5018
Hi UV	Correlación de Pearson	0.457**	0.416**	0.403**	0.452**	−0.026	−0.023	0.968**	0.993**	0.993**	1
	Sig. (bilateral)	0	0	0	0	0.066	0.103	0	0	0	
	N	5018	5018	5018	5018	5018	5018	5018	5018	5018	5018

Table 8. Explanation of the most significant correlations.

(a)	The correlation is between the **UV index** and the **level of solar energy (Solar Energy)**, which are strongly related. It is observed that its correlation value is **0.967**, so the conclusion is that a higher level of solar energy generates a higher index of UV rays that can reach people

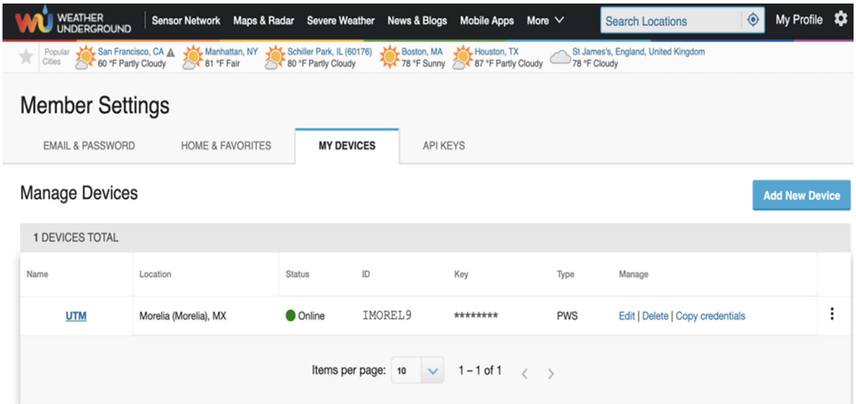

Fig. 9. Active UTM weather station log on the weather underground server.

4.2 Manage Data Loading

Through the web control system of the Meteorological Unit (WEATHERLINK), the UM-UTM is linked to the Weather Underground data server with the access codes provided, establishing the sending of data every 15 min, as shown in Fig. 10.

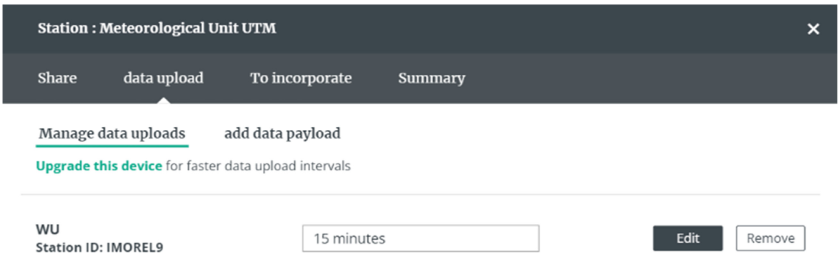

Fig. 10. Management of data upload to the weather underground server.

4.3 Building APIs for Data Recovery

Using the connection parameters provided by the Weather Underground server, the data recovery API is set using the readings obtained from the Meteorological Unit - UTM, as shown in Fig. 11.

Fig. 11. Reading UM-UTM data from the API.

Figure 12 shows the process for communicating the software system and the containers (application, data storage, and microservices) that make up this system.

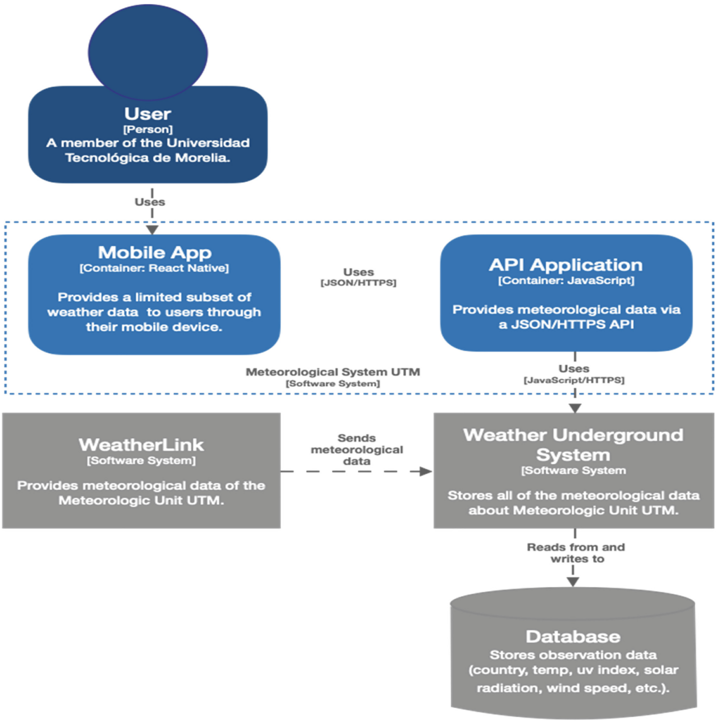

Fig. 12. Communication process of the software system and containers.

According to the WHO, the level of UV rays is classified into five categories: exposure to sun radiation, damage, and suggested recommendations [15]. These are shown in Table 9.

Table 9. UV index scale.

UV Index	Risk	Colour	Recommendations
1–2	Low		No protection needed. You can safely stay outside using minimal sun protection
3–5	Moderate		Seek shade during late morning through mid-afternoon. When outside, generously apply broad-spectrum SPF 30 + sunscreen on exposed skin, and wear protective clothing, a wide-brimmed hat, and sunglasses
6–7	High		Protection needed. Seek shade during late morning through mid-afternoon. When outside, generously apply broad-spectrum SPF 30 + sunscreen on exposed skin, and wear protective clothing, a wide-brimmed hat, and sunglasses
8–10	Very Higt		Be careful outside, especially during late morning through mid-afternoon. If your shadow is shorter than you, seek shade and wear protective clothing, a wide-brimmed hat, and sunglasses, and generously apply a minimum of SPF 30 +, broad-spectrum sunscreen on exposed skin
11 +	Extreme		Extra protection needed. Be careful outside, especially during late morning through mid-afternoon. If your shadow is shorter than you, seek shade and wear protective clothing, a wide-brimmed hat, and sunglasses, and generously apply a minimum of SPF 30 +, broad-spectrum sunscreen on exposed skin

The UM - UTM mobile app retrieves the API data, showing: (1) the reading date, (2) temperature, (3) wind chill, (4) solar radiation and (5) humidity and UV index; these variables are evaluated under the recommendation of the practical guide coordinated by the WHO and the EPA as shown.

Figure 13 shows the interfaces where the alerts are presented in the Meteorological Unit – UTM mobile application, as well as the recommendation proposed to the users to take care of their health and protect themselves against UV rays.

5 Conclusions

- The previous research determined that ultraviolet (UV) radiation from sunlight is among the environmental components with the highest incidence of skin lesions and causes diseases such as cancer. However, the effect of UV rays on people has had a negative impact in recent years, in addition to being a topic not visible to society generating misinformation about the data and the effects that this causes on human health.

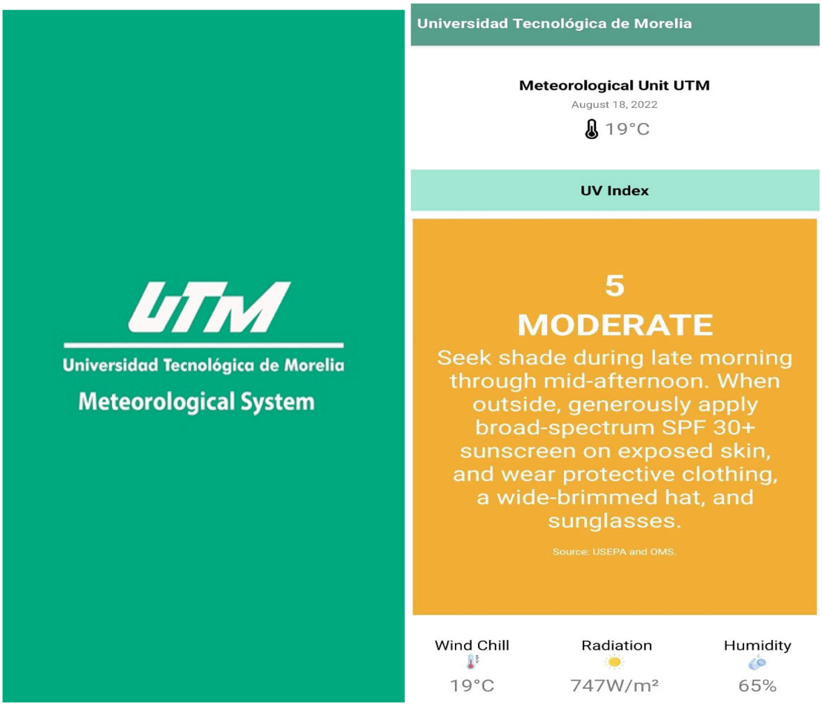

Fig. 13. Home screen of the mobile application using data from the meteorological unit - UTM. And present moderate level index, obtained from the mobile application of the UM – UTM.

- Through the UM – UTM weather station, the UV indices are sensed every fifteen minutes, which are stored in the Weather Underground System server and can be consulted in real-time with the mobile application through the built API.
- In addition to presenting a suggestion of what the user can do to protect themselves and avoid the effects and damages it can cause to the skin. Based on the information stored and as future work, the mobile application will generate predictive alerts based on the history hosted in the dataset of the UM – UTM and build a predictive model through Machine Learning that aims to know the states of the variables that produce the highest levels of the UV indices.
- It is vital to pay greater attention to this problem and generate educational programs in schools that publicize the harmful effects of UV radiation and promote changes in the lifestyle of today's society. In addition, young people must understand that skin diseases can cause severe irreversible damage, but they can take care of their health through the care proposed by the World Health Organization.

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Author Index

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